Behavioral and Physiological Responses to a Name Call in Young Children with Autism Spectrum Disorders in Comparison with Typically Developing Children

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ABSTRACT

MARGARET DERAMUS: Behavioral and Physiological Responses to a Name Call in Young Children with Autism Spectrum Disorders in Comparison with Typically Developing Children
(Under the direction of Dr. Linda Watson)

The current study aimed to determine whether children with autism spectrum disorder (ASD) present differences in 1) behavioral and/or 2) physiological responses to a name call compared with language age (LA) and chronological age (CA) matched typically developing (TD) peers. During an experimental session, each child watched a nonsocial video while surface electrodes measured heart rate data. An examiner presented the child's name every 15 seconds for up to one minute until a head turn was observed. Boys with ASD showed reduced behavioral response compared with both TD groups. The change in heart rate was analyzed using several methods, and all results were reported. Some results revealed that children with ASD demonstrate a small increase in heart rate in response to the name call, suggesting that young boys with ASD may have a mildly aversive or defensive physiological response to name call. Possible explanations for these findings are explored.

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LIST OF ABBREVIATIONS

ANS	autonomic nervous system
ASD	autism spectrum disorder
CA	chronological age
ECG	electrocardiogram
IBI	inter-beat interval
LA	language age
PNS	parasympathetic nervous system
SNS	sympathetic nervous system
TD	typically developing

CHAPTER 1

INTRODUCTION

Research has shown that children with autism spectrum disorder have decreased orienting responses to social stimuli (Baranek, 1999; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Leekam, Lopez, & Moore, 2000; Mosconi, Reznick, Mesibov, Piven, 2008). Orienting behaviorally to a stimulus has been associated with a decrease in heart rate in typically developing children (Richards and Casey, 1991; Casey and Richards, 1991; Lansick and Richards, 1997; Van Hover, 1974; Vila, Guerra, Munoz, Vico, Viedma-del Jesus, Delgado, Perakakis, Kley, Mata, and Rodriguez, 2007). However, currently, there is limited research regarding heart rate changes in response to orienting among children with ASD, and the addition of this information to the literature would allow a fuller understanding of the lessened behavioral responses. This knowledge may also assist clinicians as they strive to create methods of gaining such orienting responses from children with autism spectrum disorder.

The current study measures the number of trials it takes for children with autism spectrum disorders to respond behaviorally to a name call, compared with children with typical development, and determines the extent to which there is a physiological change in heart rate in response to a social stimulus, specifically a name call, for children in each group. The primary questions answered in this study: when presented with a name call, are there differences in (1) behavioral responses in terms of a head turn toward an examiner and/or, (2) physiological responses in terms of heart rate of a group of children with autism spectrum disorders (ASD) when compared with a group of typically developing (TD) children?

Background

<u>*Autism Spectrum Disorders and Social Attention*</u>

Autism spectrum disorders are characterized by impairments in communication and social interaction, as well as repetitive behaviors and restricted interests (American Psychiatric Association [DSM-IV-TR], 2000). Because children with ASD tend to have difficulty navigating the social world, it can inhibit their learning and other life experiences. Therefore, it is crucial to understand the underlying factors that contribute to the lack of social abilities. It has been demonstrated that children with ASD have impairment in orienting to social stimuli (Baranek, 1999; Dawson, et al., 1998; Leekam, et al., 2000; Mosconi, et al. 2008). Specifically, lack of response to name call is one of the early hallmark signs of ASD and indicates impairment in social interaction as described by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition-Text Revision* (*DSM-IV-TR*, 2000). The Autism Diagnostic Observation Schedules (ADOS), which are designed to assess the criteria of ASD presented in the *DSM-IV-TR*, includes a name call task in the module for children with limited or no expressive language to assess whether a child attends to the social stimulus (Lord, Risi, Lambrecht, Cook, Leventhal, DiLavore, Pickles, and Rutter, 2000).

The Social Orienting Continuum and Response Scale (SOC-RC) is a more recently developed tool used to look exclusively at social behaviors during a previously recorded ADOS assessment. This measure also obtains a specific score that is based on the number of trials until a child responds to his name called by an examiner or parent. The research on this measure identifies a diminished response to name call as a core social impairment for children with autism (Mosconi, et al. 2008).

In a prospective longitudinal study of infants at risk for ASD compared to infants with no identified risk (Nadig, Ozonoff, Young, Rozga, Sigman, & Rogers, 2007), researchers examined the responses of children later diagnosed with ASD to name call.

These researchers proposed that orienting to a name call is an intrinsically social behavior, rather than a receptive language skill. The results suggested that, compared to language level, a better predictor of response to name call was the number of times a child demonstrated joint attention gaze shifts with an experimenter during an attention-shifting task.

On the whole, studies in the literature regarding behavioral responses are in agreement that children with ASD have reduced orienting responses to social stimuli and specifically a name call. These orienting and attention skills are key during a child's development, because attending to adults and understanding where they are looking or to what they are referring is one way that infants and children gain knowledge and language about the world around them. At times, a child's name is called when an adult is directing the child's attention. If the child does not respond to his name, he misses the opportunity for learning. Failure to orient to social stimuli is considered one of the earliest symptoms of ASD (Baranek, 1999; Dawson, et al.1998; Wetherby, Woods, Allen, Cleary, Dickinson, and Lord, 2004) and may be one factor that leads to subsequent language delays.

Autonomic Nervous System, Attention, and Heart Rate

Attention and alertness are regulated by the autonomic nervous system (ANS), which is comprised of the sympathetic nervous system (SNS) and parasympathetic nervous system (PNS), both of which contribute to an individual's autonomic response to a stimulus. The SNS and the PNS act reciprocally to balance out responses to stimuli (Althaus, Van Room, Mulder, Mulder, Aarnoudse, and Minderaa, 2004). In a typically developing child, the SNS accelerates the heart rate in a fight-or-flight or aversive response, whereas the PNS decelerates heart rate in situations requiring orienting and sustained attention (Beauchaine, 2001; Sigman, Dissanayake, Corona, and Espinosa, 2003). Graham and Clifton (1966) reviewed several studies and concluded that orienting responses were generally accompanied by heart rate deceleration and that in the cases of an initial acceleration, the increase could be attributed to a startle reflex.

Porges (1995) suggests that the slowing of heart rate affects perception and the ability to process information regarding the surrounding environment. Accordingly, it has been demonstrated that typically developing infants and young children experience deceleration in heart rate during orienting to stimuli (Richards et al., 1991; Casey et al., 1991; Lansick and Richards, 1997; Van Hover, 1974; Vila, et al., 2007). In addition, Porges (1995) proposed that reduced autonomic adaptivity might indicate "a deficiency in the functional organization of the neural pathways that provide cortical control of the visceral efferents," a system he claims is the source of communication and social engagement (Porges, 1995; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996).

Hence, the conclusions emerging from this body of research are first that orienting in a non-threatening situation is associated with a slowing of heart rate, which prepares the individual for more adaptive cognitive processing of the stimulus following the initial orienting; and secondly, in contrast, stimuli eliciting a startle response are associated with heart rate acceleration, which prepares the individual to try to escape or avoid the situation.

Autism, Orienting, and Heart Rate

As described above, at the physiological level, an orienting response to a task such as name call would be expected to activate the ANS and decrease the heart rate in a typically developing individual; however, children with ASD have been shown to have dampened autonomic regulation during attention-demanding tasks using visual and/or auditory stimuli (Ming, Julu, Brimacombe, Connor, and Daniels, 2005; Axelrod, Chelimsky, and Weese-Mayer, 2006). One study demonstrated that the heart rate of children with ASD did not change in response to an examiner who pretended to hit her knee, but the children with developmental delays did show a response relative to their baseline heart rate (Corona, Dissanayake, Arbelle, Wellington, & Sigman, 1998).

In 1982, Kootz, Marinelli, and Cohen demonstrated that children with autism, especially those who are lower functioning, often respond to novel stimuli with avoidance and increase in heart rate rather than orientation. In a separate study, Kootz and Cohen (1981) proposed that children with autism not only demonstrate a diminished physiological response but also decreased behavioral responses to tasks.

Goodwin (2006) looked at heart rate responses of children with autism to several potential stressors, and found that this group demonstrated diminished cardiac responsiveness when compared to typically developing peers. He suggested that this finding might be due in part to their higher baseline heart rate and reduced variance in responsiveness, exhibiting about half the response of the TD group. He also suggested individuals with autism who demonstrate "high basal heart rate are unable to elicit significantly greater increases in cardiovascular reactivity to environmental stimulation." He considered that this inability to react physiologically might be attributed to the idea that "the group with autism was either overly aroused by the testing situation on the whole… or in a general state of *autonomic defensiveness*" (Goodwin, 2006).

The only study that addresses responses of children with autism to a social stimulus similar to the current study ("Listen to me, [name]"), showed that the ASD group had a diminished deceleration in heart rate in response to auditory stimuli when compared to a typically developing group (Palkovitz and Wiesenfeld, 1980). In this study, the ASD group also demonstrated a tendency to respond to more social stimuli with an initial minimal slowing of heart rate within one second following the stimulus followed by a secondary acceleration of heart rate that has been associated with a defensive autonomic pattern. Conversely, the TD group demonstrated “a sharp deceleration at one second poststimulus onset and a gradual return to baseline over the next 5 seconds” (Palkovitz, 1980).

In brief, the body of research, examining the physiological responses of children with ASD when orienting to stimuli, has generally demonstrated diminished heart rate responses. In some of the studies, children with ASD displayed an increase in heart rate, instead of the expected orienting response of a decrease in heart rate. Some researchers have attributed this acceleration to either a general state of over-arousal or autonomic defensiveness in the ASD population, while others claim it may be due to an avoidance response. Presently, no research demonstrates whether children with ASD respond physiologically to name call, and so it remains unclear whether reduced physiological responses would accompany a reduced behavioral response.

Current Study

The current study is a secondary analysis of data collected during Dr. Linda Watson’s Language Outcomes Project (National Alliance for Autism Research/Autism Speaks #681). The purpose of the original study was to determine the extent to which behavioral and physiological measures of attention to child-directed speech predict social-communicative outcomes in young children with ASD. The name call was the first of a series of child-directed speech stimuli presented to children with ASD and typically developing children. These data have not been previously coded or analyzed. For the current study, data from the name call section were coded for behavioral (head turn) and physiological (heart rate) responses. The purpose of the present study is to examine whether children with ASD have a different (1) behavioral and/or (2) physiological response to a name call when compared with a TD group.

Evidence already indicates that children with ASD have a reduced behavioral response (head turn) to name call (Baranek, 1999; Leekam and Ramsden, 2006; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Osterling, Dawson, and Munson, 2002; Wetherby, et al., 2004). The ability to direct attention to social stimuli such as a name call is an important aspect of social communication. Parents, teachers, and other persons involved with a child use name call to orient a child to his surroundings, initiate social interactions, give verbal and non-verbal information, and keep him out of harm's way. If a child fails to respond to his name, he may miss learning opportunities and social experiences.

Because there is a paucity of literature on the physiological orienting response of children with ASD to social stimuli, results of the present study can contribute to the knowledge base and research about orienting responses of children with ASD. If children with ASD demonstrate a covert physiological orienting response in absence of a behavioral response, it might indicate that this group is responding auditorily. This covert response to stimuli would indicate that there is indeed an internal orienting response to the stimulus, and the breakdown exists solely in the behavioral response. Conversely, if the children with ASD demonstrate an absent or diminished physiological response to the name call stimulus, it would suggest the deficit may be more involved at the level of the function of the autonomic nervous system.

Given results in previous literature, it was hypothesized that children with ASD would (1) show a diminished behavioral response to name call, thereby replicating findings of previous research; and (2) differ from TD children in heart rate response to name call.

CHAPTER 2

METHODS

Participants

In the original study, twenty-three boys with autism spectrum disorders ranging in ages 28 to 42 months (*M* = 35.1, *SD* = 4.2) were recruited through the Neurodevelopmental Disorders Research Center Autism Research Registry, which includes individuals diagnosed with ASD throughout North Carolina. Twenty-nine typically developing boys, ranging in ages 6 to 32 months (*M* = 22.6, *SD* = 11.3), were recruited for the control group through electronic advertisements and through a collaborating study. The typically developing boys were matched in either language age (*N* = 15) or chronological age (*N* = 14) to the boys with ASD, as seen in Table 1. All participants were screened to exclude any individuals with known metabolic, genetic, and progressive neurological disorders, and physical impairments. All participants were screened for visual and hearing acuity within normal or corrected normal ranges.

For the children in the ASD group, diagnosis was confirmed with the Autism Diagnostic Observation Scale (Lord, et al., 2000), the Autism Diagnostic Interview-Revised (Rutter, Le Couteur, and Lord, 2003), and the Childhood Autism Rating Scale (Schopler, Reichler, & Renner, 1994). For all participants, language age was determined by the Preschool Language Scale - Fourth Edition (PLS-4), (Zimmerman, Steiner, & Pond, 2002). The PLS-4, standardized for children aged birth through 6 years, 11 months, includes two subscales: Auditory Comprehension and Expressive Communication, providing an observational equivalent of the child’s receptive and expressive language. In addition, all participants were assessed using the Mullen Scales of Early Learning, a standardized assessment that determines developmental levels of children aged birth through 5 years, 8 months in the following five domains: Gross Motor, Visual Reception, Fine Motor, Expressive Language and Receptive Language. Using all five domains, an Early Learning Composite score was obtained (Mullen, 1995).

Table 1

Group Means of Participants' Chronological Ages and Language Ages (PLS-4)

Group	N	CA	LA
ASD	23	35.06 m (4.19)	11.78 m (6.30)
TD_CA	14	32.93 m (6.12)	42.14 m (10.04)
TD_LA	15	12.87 m (3.78)	14.40 m (4.07)

Procedures

Following recruitment, consent packets were sent to the families along with practice electrodes to place on the participants' chest to desensitize the children to the heart rate data collection procedures ahead of time.

Each participant came in for the study protocol in the morning in order to control for the effect of circadian rhythm on physiological variables. The child was seated in a high chair facing a stimulus window three feet in front of him; the child's caregiver sat to the side and slightly behind him. A wide-angle camera and microphone were placed just above the stimulus window to record the participant's behavior.

Surface electrodes, which transmitted cardiac activity data to the Mini-Logger 2000 (Mini Mitter Co., 1994), a radiotelemetry system, were then placed on the child's anterior chest wall. The electrodes detected electrocardiogram (ECG) waves generated by cardiac activity and sent this signal to the transmitter; in turn, the waves were sent to a receiver placed within three feet of the transmitter.

Once the child was situated and electrodes were detecting cardiac activity, a non-social stimulus, specifically a "Baby Bach" music video, was played for three minutes. The first two minutes allowed a child to become settled before any social stimulus was presented. While the video continued during the third minute, the social stimulus, specifically a name call, was presented by a female examiner, who sat either three feet to the left or right (counterbalanced across participants) of the child. Simultaneously, the onset of each stimulus trial was clearly marked in the data files using the event marker button provided with the cardiac monitor in order to synchronize the behavior data with the heart rate data. The child's name was presented every fifteen seconds for up to one minute (up to five trials) until a clear behavioral response, a turn of the head toward the examiner, was observed.

In order to verify that children with autism have reduced behavioral responses to name call, the number of stimulus presentations, or trials, until a clear behavioral response was coded (1 - 5); a trained coder watched the videos of each participant to determine and code a behavior change, defined as a head turn of at least 45 degrees toward the examiner and away from the video, occurring within five seconds. If a child did not respond to any of the trials (1 - 5), the coder recorded a 6 for no response and a 7 was coded for a mistrial. This coding system was similar to that of Nadig (2007) and Mosconi (2008). Additionally, a second coder was trained to code the behavioral responses, and coded 100% of the videos for reliability.

Following the study, to preserve data integrity, the cardiac data were edited by editors trained to high reliability in using the software package, MxEdit (Delta-Biometrics, 1989), which eliminated artifacts in the cardiac data. The registration of the heart rate was successful for 40 children (ASD (*N* = 17), CA (*N* = 11), LA (*N* = 12). Exclusion of participants resulted from inability to gain data due to behavior, loss of data, or greater than 20% of data needing editing of all heart rate data collected over the entire 25 minutes of the experimental trials in the original study. In such cases that the physiological data were lost, the intact behavioral data were still used for analyses.

The physiological unit of measure of heart rate was the inter-beat interval (IBI), which is the duration in milliseconds between two consecutive heartbeats (R-wave), also termed heart period. There is a reciprocal relationship between heart rate and IBI: when the IBI is shorter, the heart rate is faster, and conversely, when the IBI is longer, the heart rate is slower. Because the differences in IBI tend to be more linear in similar age ranges, using IBI is preferred over beats per minute as a measure to analyze physiological data (Courage, et al. 2006). For the purposes of this paper, the heart rate is referred to interchangeably with heart period.

Change in heart rate was determined initially by calculating the mean difference between the averages of 10 IBIs before and 10 IBIs after each stimulus. Children in the age range included in this study have resting IBIs of approximately 0.5 seconds, and therefore 10 IBIs are equivalent to approximately five seconds. Several researchers who previously have examined change in heart rate used the mean of five-second pre-stimulus and post-stimulus intervals to look at baselines and orienting response (Richards et al., 1991; Courage, et al. 2006; Naber, Swinkles, Buitelaar, Bakermans-Kranenburg, Ijzendoorn, Dietz, Daalen, Engeland, 2007). Similarly, Van Hover (1974) used the mean heart periods of a five-second baseline and an eight-second orienting interval.

For the purposes of this study, the available IBI data consisted of approximately 10 seconds prior to the initial name call trial and approximately 20 seconds after a clear behavioral response determined by the examiner during the experimental session. During initial exploration of the data, the researcher became concerned that change scores based on a 10 IBI baseline and 10 IBI orienting period might not be reflective of important parameters in the physiological responses of the children to name call. A further review of the literature related to such measurements revealed concerns by a prior investigator that the mean of IBIs over a period of 10 seconds may eliminate some the essential properties of the data (Graham, 1978). When a mean of heart period is calculated, it biases the results, concealing the expected variability between intervals and within the subset of intervals following stimulus, as each IBI is not expected to be equally weighted following a stimulus. In addition, in the data analyzed for the current study, there were sudden novel tones in the music video that occurred between 5-10 seconds before the first name call, and the data exploration suggested that the children's physiological response to that novel tone might be affecting the putative baseline data during the 10 IBI prior to the first name call. It has been demonstrated in TD children that heart rate recovery period following a physiological orientation response occurs within approximately 2-5 IBIs after a stimulus (Colombo, 2001; Palkovitz, et al., 1980).

For these reasons, several methods were attempted to measure the change in heart rate to preserve these properties of the data. First, similar to the method of Palkovitz (1980), a new one-second baseline was created using the mean of two IBIs before and the IBI at the time of the name call trial. Second, the longest and shortest IBIs among the first 10 intervals after the name call were identified in order to calculate the percentage of change from the baseline. All outcomes of these calculations were reported in the results along with those of the initial proposal to examine the change from 10 IBI mean baseline.

Due to the varying number of trials needed to elicit a behavioral response and the confounding variables, such as habituation, that arise with each subsequent trial, only the physiological data from the first trial were examined.

Data Analyses

For the head turn code, 100% of the videos were double coded by two trained coders. Inter-rater reliability was calculated using point-by-point agreement, and the two coders were shown to be 95.8% reliable for the head turn code. A Mann-Whitney U-test was performed to analyze the behavioral data. Additionally, Spearman rank-order correlation analyses were performed to examine the relationship between the behavioral responses to name call and PLS-4 Auditory Comprehension age equivalent scores in all participants, and each group separately.

One-way analyses of variances (ANOVA) were performed to look for differences in the baselines among groups. When comparing the ASD group with the TD group as a whole (combining the CA and LA groups), physiological data were analyzed using repeated measures analyses of covariance (ANCOVA), with chronological age as a covariate, to examine the within subjects factor of the baseline heart rates and the mean response period of 10 IBI following the initial name call trial. Similarly, repeated measures ANOVAs were performed to compare the heart rate changes when comparing the ASD group with the CA and LA groups separately. Additional repeated measures ANCOVAs and ANOVAs were run to examine the differences in proportion of change to the longest and shortest IBIs in 10 intervals following the name call stimulus.

Finally, a Spearman's Rho correlation was performed to examine the relationship between number of name call trials until a behavioral response and the change in heart rate in the ASD group.

CHAPTER 3

RESULTS

Behavioral Responses

In accordance with the current literature describing a diminished behavioral response to social stimuli and specifically a name call, it was hypothesized that a similar trend would be demonstrated in this study. The behavioral data indicated that children with ASD demonstrated a significant delay in response to a name call stimulus ($U = 95.5$, $N1 = 22$, $N2 = 26$, $p = 0.000$) when compared with the TD group using a Mann Whitney U-Test. The percentages of groups to respond at each name call trial are presented in Figure 1.

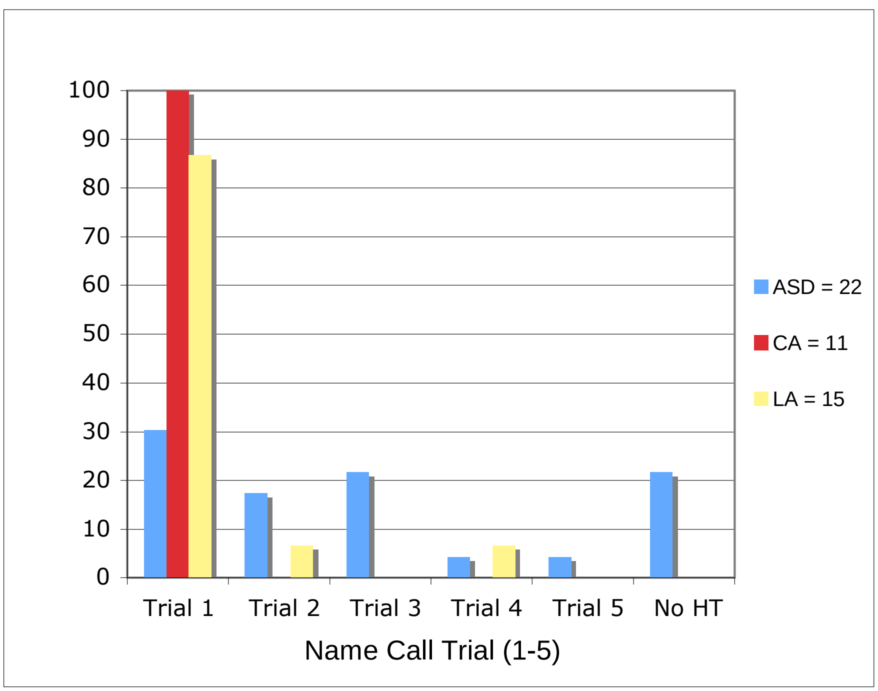

Figure 1: Percentages of groups to respond behaviorally to name call at each trial

In a bivariate correlation analysis (Table 2), the ASD group showed a significant relationship between the receptive language scores and number of trials until a behavioral response to name call. In addition, a correlational analysis, examining participants from all groups combined, yielded a significant correlation. In contrast, the correlational analysis of the children in the CA and LA groups individually demonstrated no significant relationship between their receptive language scores and response to name call. These relationships are displayed in Figure 2.

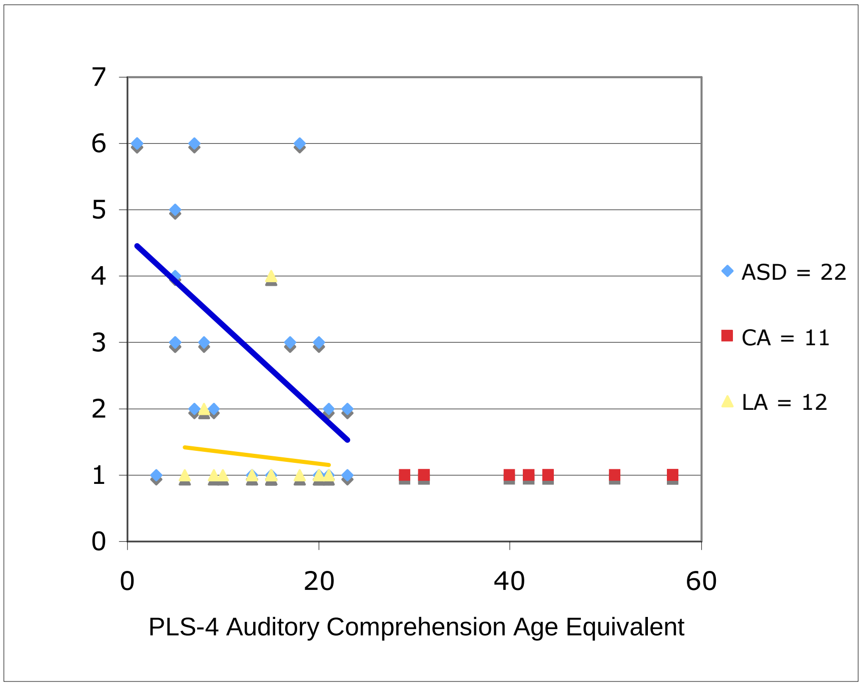

Figure 2: Correlation of Receptive Language and Number of Trials until a Behavioral Response to Head Turn

Table 2

Spearman's Rho Correlation of Head Turn Response Related to PLS-4 Auditory Comprehension Age Equivalent Scores

Group	N	Spearman's rho	Sig.
All	48	-0.587	0.000
ASD	22	-0.565	0.003
LA	15	-0.259	0.176

Physiological Responses

A variety of methods were utilized to calculate change of heart rate in response to the name call. As mentioned before, two baseline measures were calculated: a 10 IBI pre-stimlulus mean and a one-second pre-stimulus mean. Using these baselines, three analyses were used to examine change in heart rate in response to the stimulus. Each baseline was compared first with the mean of 10 IBI immediately following the name call; second, with the longest IBI in 10 intervals following the name call; and last, with the shortest IBI in 10 intervals following the name call. In addition, all of these analyses were completed looking at differences (1) between the ASD and the combined TD group and (2) among the ASD, CA, and LA groups separately.

Analyses of Baselines

Because some studies have suggested that children with ASD have a generally higher baseline heart rate due to a general state of over-arousal or autonomic defensiveness, the differences in each of the baseline heart rates of the ASD, CA, and LA groups were examined using a one-way analysis of variance (ANOVA). The within group comparisons (Table 3) demonstrated a significant difference among the three groups for both baselines; however, that outcome is to be expected, since the LA group is younger, and infants tend to have higher heart rates. As seen in Tables 4 and 5, the multiple comparisons revealed that no significant differences were found between the ASD and CA groups for either baseline.

Table 3

One-way ANOVA of Baseline Differences in ASD, CA, and LA Groups

Baseline	Group	N	M	SD	F (2,37)	Sig.
	ASD	17	533.97	53.44		
10 IBI pre-stimulus	CA	11	553.48	61.99	4.777	0.014*
	LA	12	487.25	44.67		
	ASD	17	536.29	62.95		
One-second pre-stimulus	CA	11	540.04	48.30	5.072	0.011*
	LA	12	479.27	40.96		

Table 4

Sheffe Multiple Comparisons of 10 IBI Baseline

Groups		Mean Difference	Std. Error	Sig.
ASD	CA	-19.51	20.72	0.645
	LA	46.72	20.19	0.082
CA	ASD	19.51	20.72	0.645
	LA	66.23	22.35	0.019
LA	ASD	- 46.72	20.19	0.082
	CA	- 66.23	22.35	0.019

Table 5

Sheffe Multiple Comparisons of One-second Baselines

Groups		Mean Difference	Std. Error	Sig.
ASD	CA	-3.74	20.63	0.984
	LA	57.03	20.10	0.026
CA	ASD	3.74	20.63	0.984
	LA	60.77	22.26	0.034
LA	ASD	-57.03	20.10	0.026
	CA	-60.77	22.26	0.034

Analyses with a 10 IBI Baseline

Tables 6 and 7 demonstrate the results from the initial proposal to examine the change in heart rate using the 10 IBI pre-stimlulus baseline. No significant differences were discovered in any of the analyses examining the change to the 10 IBI post-stimulus mean, to the longest IBI, or to the shortest IBI of 10 intervals following the first name call trial when comparing the ASD group with the combined TD group or the CA and LA groups separately.

Table 6

Repeated Measures ANCOVA of ASD and TD Groups for the 10 IBI Baseline

10 IBI baseline Comparison of ASD and TD groups	F (1,37)	Sig.	Partial Eta Squared
Change to mean of 10 IBI post NC	0.249	0.621	0.007
Change to Longest IBI	0.500	0.484	0.013
Change to Shortest IBI	0.048	0.828	0.001

Table 7

Repeated Measures ANOVA of ASD, CA, and LA Groups for the 10 IBI Baseline

10 IBI baseline Comparisons of ASD, CA, and LA groups	F (2,37)	Sig.	Partial Eta Squared
Change to mean of 10 IBI post NC	0.395	0.676	0.021
Change to Longest IBI	0.322	0.727	0.017
Change to Shortest IBI	0.190	0.828	0.010

Analyses with a One-second Baseline

The outcomes of the analyses, which examined change in heart rate relative to the one-second pre-stimulus baseline are displayed in Table 8 and Table 9. First, the

ASD group was compared with the combined TD group using repeated measures ANCOVAs, entering chronological age as a covariate. In this analysis, the change to the mean of 10 IBI following the name call revealed a significant difference. The analysis of the change to the longest IBI approached significance, but the change to the shortest IBI revealed no significant difference. No significant differences were found for the one-second baseline when examining the ASD, CA, and LA groups separately using repeated measures ANOVAs.

Table 8

Repeated Measures ANCOVA of ASD and TD groups for the One-second Baseline

One-second IBI baseline Comparisons of 2 Groups	F (1,37)	Sig.	Partial Eta Squared
Change to Mean of 10 IBI post NC	4.445	0.042	0.107
Change to Longest IBI	3.302	0.077	0.082
Change to Shortest IBI	1.191	0.282	0.031

Table 9

Repeated Measures ANOVA of ASD, CA, and LA groups for the One-second Baseline

One-second IBI baseline Comparisons of 3 Groups	F (2,37)	Sig.	Partial Eta Squared
Change to mean of 10 IBI post NC	2.191	0.126	0.106
Change to Longest IBI	1.167	0.322	0.059
Change to Shortest IBI	0.908	0.412	0.047

Because a significant difference was discovered when looking at the change from the one-second baseline to the mean of the 10 IBI after the name call for the ASD and TD groups, the direction of change was examined to determine whether the children in the groups demonstrated an overall increase or decrease in heart rate. As seen in Table 10, the children in the ASD group demonstrated an overall decrease in IBI (M = -22.4), which indicated acceleration in heart rate; however, the TD group showed a slight increase in IBI (M = 4.0), indicating a minimal deceleration in heart rate.

Table 10

Change from One-second Baseline to 10 IBI post Name Call

				95% Confidence Interval	
Group	Variables	Mean	Std. Error	Lower Bound	Upper Bound
ASD	One-second Baseline	520.0	14.429	490.714	549.188
	10 IBI post Name Call	497.6	11.938	473.433	521.808
TD	One-second Baseline	520.4	12.100	495.893	544.928
	10 IBI post Name Call	524.4	10.010	504.090	544.656

In addition, the longest IBI and the shortest IBI were examined more closely for patterns within the 10 intervals following the name call stimulus. Figures 3 and 4 display the percentage of the ASD and TD groups, respectively, to demonstrate their longest IBI and shortest IBI at each of the 10 intervals following the name call stimulus. It can be seen in Figure 3 that the ASD group tended to experience the longest IBI, or slowest heart rate, in the earlier intervals, and the shortest IBI, or fastest heart rate in the later intervals. Conversely, the TD group tended to demonstrate the shortest IBI, or fastest heart rate, at an initial interval and the longest IBI, or slowest heart rate at a later interval. Finally, Figure 5 demonstrates the percentage of groups to reach the longest and shortest IBI in 10 intervals following the name call and reveals a similar pattern. To summarize, in general, the ASD group demonstrates the longest IBI at an earlier interval and the shortest IBI later, demonstrating a trend to accelerate heart rate over the 10 intervals following the name call. On the contrary, the TD group experiences the shortest IBI at an earlier interval and the longest IBI later, which shows a deceleration in heart rate over the 5 seconds following the name call.

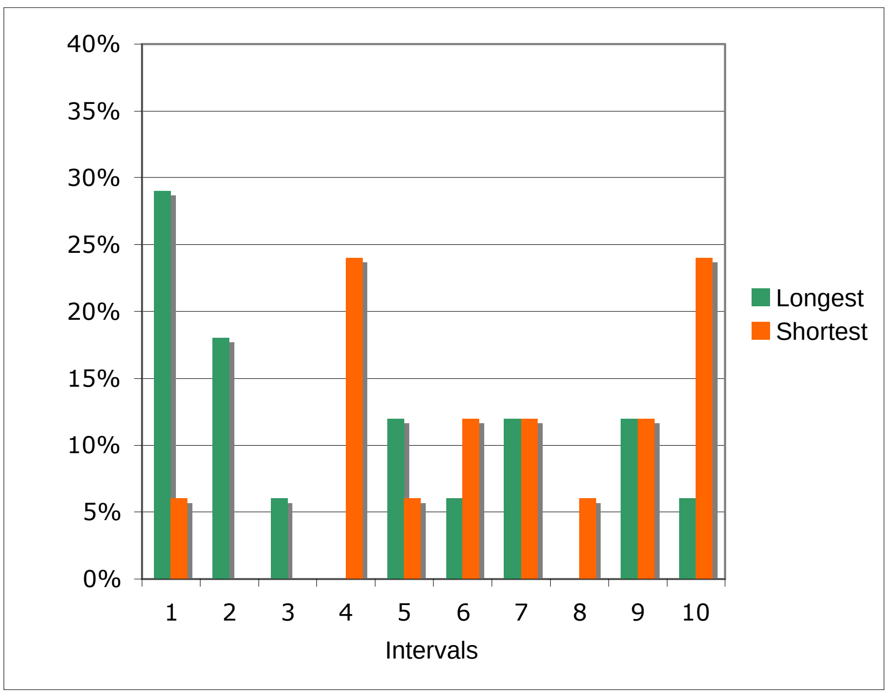

Figure 3: Percentage of ASD Group to Respond with Longest and Shortest IBIs at each of 10 Intervals Following the First Name Call Trial.

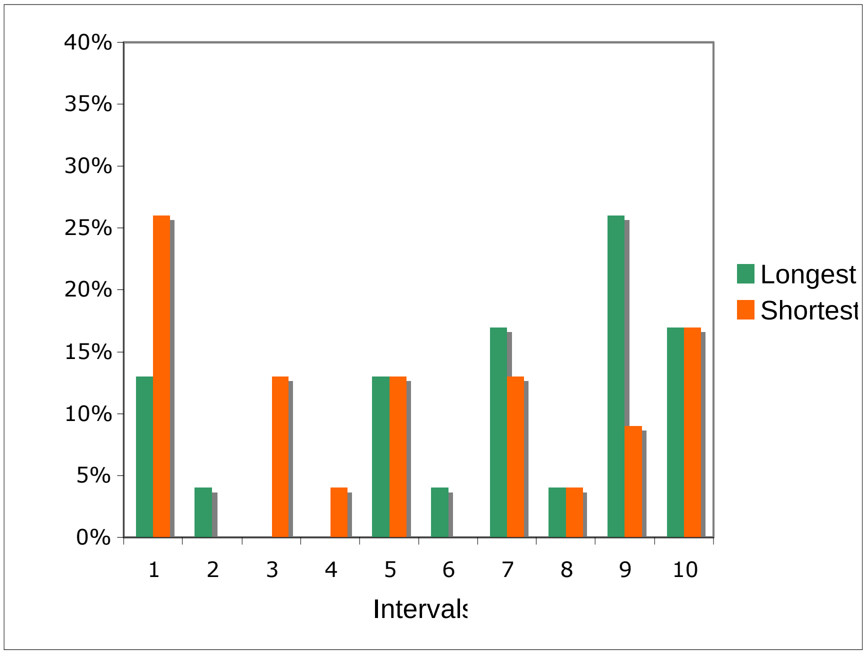

Figure 4: Percentage of TD Group to Respond with Longest and Shortest IBIs at each of 10 Intervals following the First Name Call Trial.

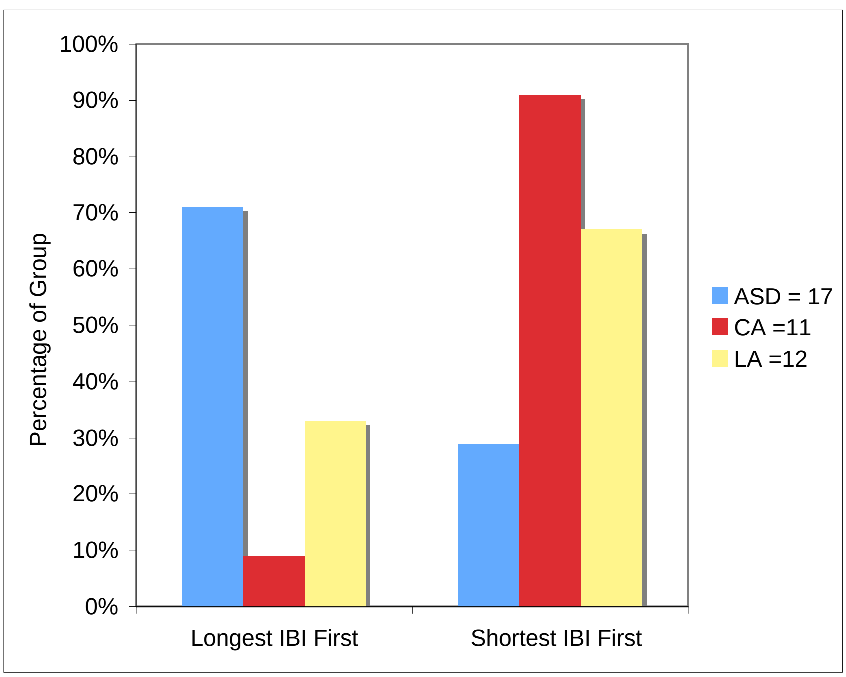

Figure 5: Percentage of ASD, CA, and LA Groups Reaching Longest or Shortest IBI First in 10 Intervals post Name Call

First Trial Responders

Because there were so few participants in the ASD group who responded to the first name call trial, the data could not be analyzed statistically to compare with the TD groups; however, Figure 6 demonstrates that even those participants in the ASD group who did respond on the first trial demonstrated an overall mean decrease in length of IBI (i.e., an acceleration in heart rate) when compared to the CA and LA groups.

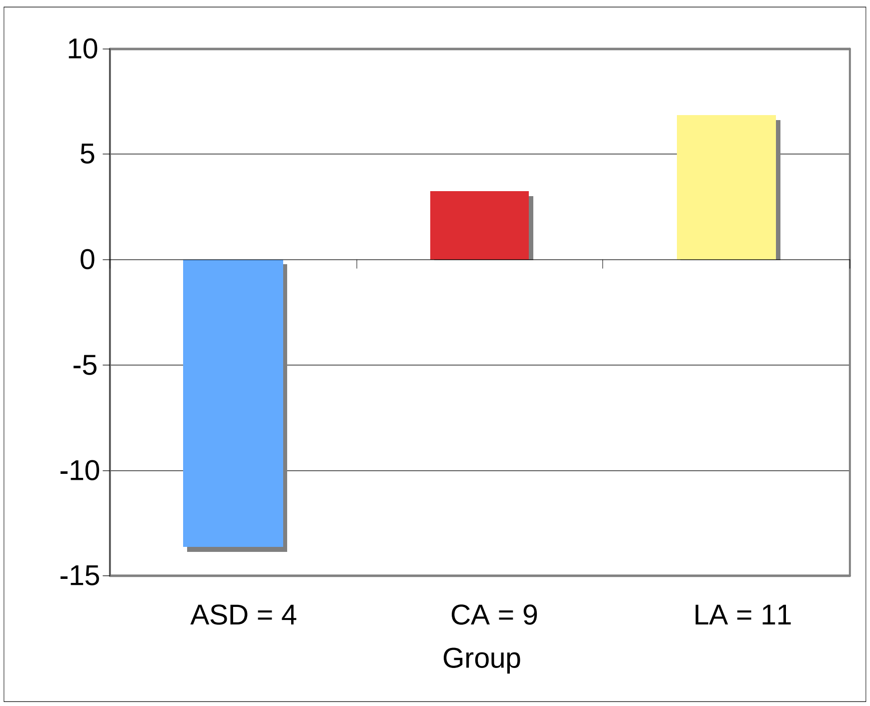

Figure 6: First Time Responders to Name Call Change in IBI from One-second Baseline

Non-Responders of ASD group

Five boys in the ASD group did not respond behaviorally to any of the name call trials. As seen in Figure 7, when examining changes from the 10 IBI baseline, four of the boys responded physiologically with a decrease in IBI (-35.8, -11.5, -17.2, -26.0), whereas one demonstrated a large increase of 62.6 IBI. When measuring the change in heart period from the one-second baseline, three of the non-responders demonstrated a decrease in IBI (- 14.0, - 45.7, -28.3); one boy demonstrated a minimal increase of 3.4 IBI; however, the same boy in the ASD group who demonstrated an increase with the 10 IBI baseline also had an increase of 52.6 IBI from the one-second baseline.

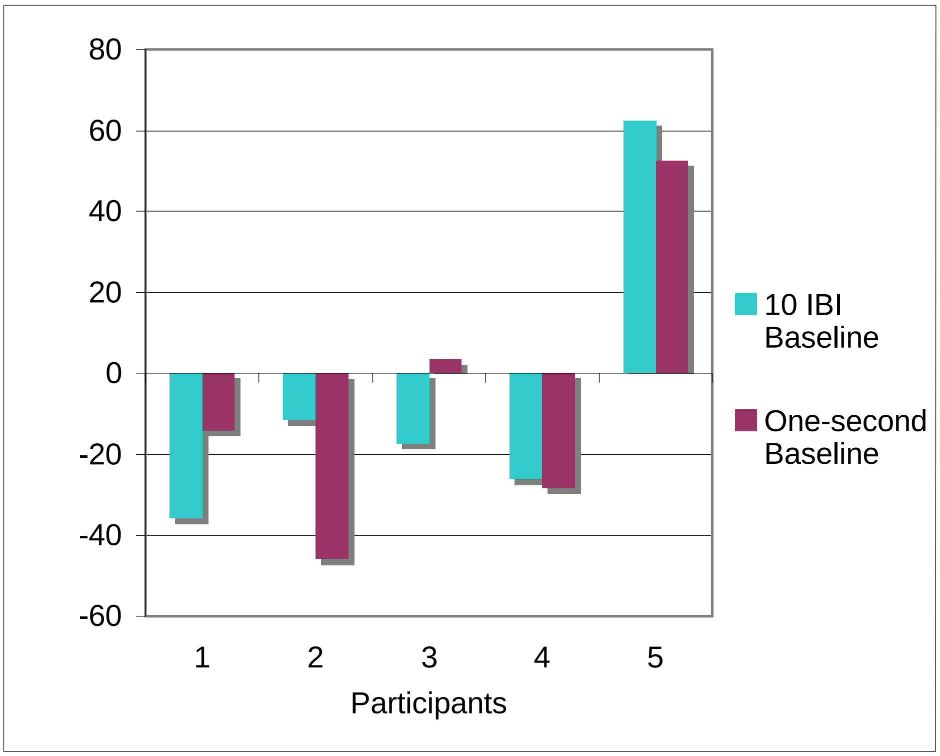

Figure 7: Heart Period Changes of Five Boys with ASD who did not Respond Behaviorally to Name Call Trials

Relationship of Behavioral and Physiological Responses in ASD Group

In order to examine the relationship between the behavioral head turn responses and the physiological heart rate responses of children with ASD, Spearman's Rho correlations were preformed (Table 11). For these analyses, the change in heart period was measured using the difference of the mean of the 10 IBI post name call from both baselines; however, no relationship was found between the number of trials until behavioral head turn response or the physiological change in heart rate in response to the first name call trial (Figures 8 and 9).

Table 11

Correlation of Behavioral and Physiological Reponses in ASD group

Baseline	**Spearman's rho**	**Sig.**
10 IBI Baseline	-0.119	0.324
One-second Baseline	-0.024	0.464

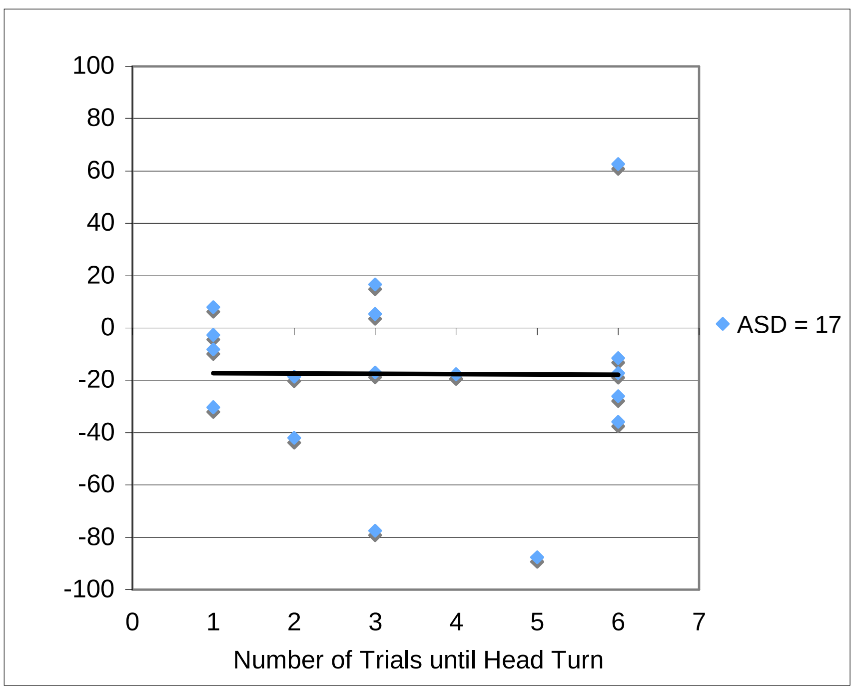

Figure 8: Correlation of Number of Head Turn Trials and Change in Heart Period from 10 IBI Baseline

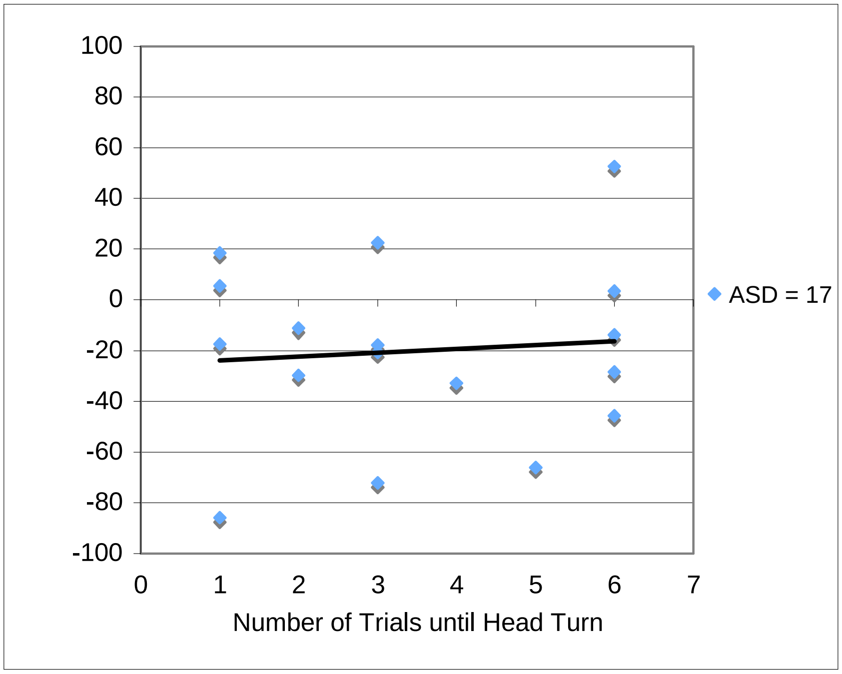

Figure 9: Correlation of Number of Head Turn Trials and Change in Heart Period from One-second Baseline

CHAPTER 4

DISCUSSION

In previous studies, children with ASD have demonstrated a diminished behavioral response to a name call (Baranek, 1999; Leekam, et al., 2006; Osterling et al., 2002; Dawson, et al., 1998; Wetherby, et al., 2004), and in some studies, have shown diminished physiological responses as well (Corona, et al. 1998; Goodwin, 2006). This study has provided insight into the nature of the orienting response of children with ASD. The results of the behavioral response were consistent with previous findings in the literature, but the physiological results provided new information about this population's response to a name call.

Behavioral Responses to Name Call

Due to the extensive body of research offering replicated evidence that children with ASD experience a diminished response to name call (Baranek, 1999; Leekam, et al., 2006; Osterling, et. al, 2002; Dawson, et al., 1998; Wetherby, et al., 2004), it was hypothesized that the participants in the ASD group of this study would demonstrate a similar trend. Indeed, the children with ASD in this study required more trials to respond to a name call, consistent with the hypothesis and literature.

Previous research has demonstrated that children with autism have more difficulty disengaging from stimuli (Landry and Bryson, 2004). Because the children in the present study were already attending to one stimulus, the "Baby Bach" video, it may have been more difficult for the ASD group to disengage, orient, and reengage with a new stimulus, in this case the name call (Posner, Cohen, & Rafal,1982; Posner and

Presti,1987). If these were the circumstances in the current study, it is possible that results of the behavioral responses were affected by the children's inability to disengage from the video. Nevertheless, because there is no research that examines the impact of disengagement on response to a name call, it is difficult to say whether or not the disengagement issue is the underlying cause of the diminished response to the name call. A future study would need to examine responses to name call across a variety of situations to see if the diminished behavioral responses only occur in situations that require the child to disengage before orienting or in all contexts.

As mentioned before, Nadig et al. (2007) observed no correlation between the receptive language scores and response to name call in children with ASD and suggested that orienting to name call is an inherently social behavior. These investigators found that the more frequently a child with ASD demonstrated joint attention shifts in gaze was a more reliable predictor of the ability to orient to one's name. However, in the current study, lower language age was associated with a lessened response to name call among the children with ASD. Conversely, the LA group did not exhibit such relationship; nearly all of these children responded to name call behaviorally on the first trial regardless of their variability in language ages. Alternative explanations for the findings of the children with ASD are that (a) these children may be processing name calls as a language comprehension task rather than processing their own names as salient social stimuli; or (b) children with ASD who do process their names as salient social stimuli are those children who have experienced more opportunities to learn language from the interactions that likely follow when a child responds to a name call. The design of the current study does not permit conclusions about which of these explanations, if either, may be a more tenable interpretation.

Physiological Responses to Name Call

Consistent with the available literature that examines heart rate responses of children with ASD when orienting to stimuli it was hypothesized that the ASD group would show a diminished physiological response to a name call. In this study, change in heart rate was examined using several methods. As initially proposed, the first method used the mean 10 IBI pre-stimulus baseline to examine the difference from the mean of 10 IBI immediately following the name call stimulus. Since Graham (1978) argued that calculating a mean of heart periods following a stimulus obscures the natural variability, change in heart rate was also examined by analyzing the baseline in relation to the longest and shortest IBI in 10 intervals following the name call. This allowed an inspection of the extent to which each group's heart rate decelerated or accelerated in response to the name call stimulus.

In addition, because there was concern about novel sounds in the video occurring within five to eight seconds prior to the initial name call trial, an additional one-second baseline similar to Palkowitz (1980) was calculated to allow for the recovery of heart rate to occur prior to the sampling of the baseline. Each baseline was utilized to look at the amount of change to three variables: the mean, the longest IBI, and the shortest IBI of 10 intervals following the name call stimulus. Furthermore, analyses were performed to examine the ASD group with the combined TD group and with the CA and LA groups separately.

Differences in Baselines Among Groups

Although some research has found that children with autism are in an already aroused state at baseline (Goodwin, 2006), no evidence was found in the current study to suggest differences in either of the baselines of the ASD group when compared with their CA peers. In fact, the one-second baseline comparison demonstrated that the baselines of these two groups were similar, which reinforces the decision to use this new baseline. This information suggests that in this study, children with ASD were not in a persistent state of over-arousal or autonomic defensiveness, which would have dampened their ability to orient physiologically like the TD group. Instead, these data suggest that children with ASD were maintaining a similar heart rate to their CA peers during baseline. However, an alternative explanation will be provided later in the discussion as to how the baseline may affect the outcomes in this study.

Results with the 10 IBI Mean Baseline

In order to be thorough and follow through with the original proposed analytic strategy, the 10 IBI baseline was employed to inspect changes in heart rate. It is uncertain whether this baseline was affected by the sounds that occurred in the video prior to the first name call trial, because the available data did not include the IBIs prior to the sound. However, the results using the 10 IBI mean baseline indicated no differences between the ASD and TD groups, combined or separately, in heart rate responses to the first name call trial.

If the 10 IBI baseline was uninfluenced by the startling sound that occurred shortly before, and these results are representative of these populations, it is possible that all participants in this study were already presenting with a lowered heart rate due to the fact that the children were already attending to a video prior to name call. Attending to the video would entail sustained attention, which is also regulated by the ANS, causing a slowed heart rate. Therefore, it is possible that the children in both groups were exhibiting an already lower than normal heart rate during the baseline before the name call stimulus was presented. In this case, it is possible that the participants in all the groups may have been unable to demonstrate the typical decrease in heart rate that one would expect when orienting to a social stimulus due to a previously established decrease in heart rate.

Results with the One-second Baseline

When examining change in heart rate utilizing the one-second baseline, there were no significant differences found among the ASD, CA, and LA groups in changes in heart rate; however, when the CA and LA groups were combined and chronological age was used as a covariate, the TD group and ASD group demonstrated a significant difference in change from this baseline to the mean of 10 IBI following the name call. Further exploration of the origin of this difference revealed the ASD group exhibited a slightly faster heart rate following name call, whereas the TD group had a slightly slower heart rate. Also, group differences approached significance when examining the baseline change to the longest IBI in 10 intervals after the name call. Similar to the findings when examining the mean of 10 IBI following name call, this finding suggested that the children with ASD do not slow their heart rate to the extent that their TD peers do, and instead tend to show a faster heart rate. This finding may indicate that the children with ASD had a startle or aversive response to the name call stimulus, as demonstrated in previous studies (Palkowitz, 1982; Kootz, et al., 1982).

Furthermore, the intervals at which the groups demonstrated the longest and the shortest IBI in the 10 intervals after the stimulus was presented were represented in Figures 3 and 4. In addition, Figure 5 demonstrated the tendency of the ASD group to reach the longest IBI first and the CA and LA groups to reach the shortest IBI first. The patterns seen in these charts were interesting, because they allowed the trends of each group to be observed. The ASD group demonstrated a trend of acceleration in heart rate, with the longest IBI being followed by the shortest, whereas the TD group revealed the opposite pattern of a deceleration in heart rate with the shortest IBI preceding the longest IBI.

Overall, the TD group did not demonstrate a significant change in heart rate in response to the name call, and again, this may have been due to the already slowed heart rate from their sustained attention to the video. If the participants were experiencing a slower heart rate before the name call was presented, there may have been a threshold factor prohibiting their heart rates to slow even further, as they would were they not already focused on another stimulus.

Interestingly, when examining the four children in the ASD group who responded to the first name call, it was seen that they showed an overall decrease in IBI, or faster heart rate, whereas the TD group did not. Similarly, when looking at the five boys in the ASD group who did not respond to any of the name call trials, most demonstrated a similar acceleration in heart rate, with the exception of one participant whose heart rate slowed in a covert physiological response. These findings suggested that the majority of the children with ASD demonstrated a faster heart rate whether they were responding behaviorally or not. Yet, these findings also convey the fact that there is variability in these responses and individual exceptions in the ASD group.

Relationship between the Behavioral and Physiological Responses in ASD Group

Interestingly, no relationship was found between the number of name call trials until a head turn and the physiological responses of the children in the ASD group. The implications of these results indicate that children with ASD who took longer to respond to a name call did not differ in change in heart rate from those who responded to earlier trials. Had there been a significantly faster heart rate among the children who had a more delayed response, it might have indicated that these children were demonstrating a more aversive or defensive response, but this was not the case in this study.

Clinical Implications

It is pertinent to note that on average, the children with ASD in this study demonstrated reflexive physiological responses to the name call. In most cases, there seemed to be a tendency to respond in an aversive or startled response, causing acceleration of heart rate; however, some of the children with ASD did show an appropriate reflexive orienting response with a deceleration of heart rate. Moreover, there were some children who demonstrated minimal response in either direction. Whether this diminished physiological response is due to a lack of a reflex or simply a result of the sustained attention creating a threshold is uncertain.

In the case that a child lacks an autonomic orientation reflex, it would be more difficult to teach a child to respond behaviorally to his name, as the reflex is the foundation of the behavior. It is possible that the reflex can be triggered through the presentation of more salient stimuli or in a more engaging approach. In order to make a name call more salient, a clinician might need to be closer to the child and use maximum prompts, modeling, and reinforcement to elicit a behavioral response.

Because this study suggests that the majority of the children with ASD had a possible, yet minimal, defensive or aversive physiological response to the social stimulus of a name call, it may elucidate why many children with ASD do not behaviorally respond to their names. In order to develop this behavioral skill in children with defensive or startling physiological responses, a clinician may need to develop strategies to lessen the possible distressing nature of the task. If the lack of response is due to an aversive reaction, it may be possible to teach the child to respond by using his interests or motivations. However, if the stimulus is startling in nature, a clinician might consider calling a child’s name quietly or in situations where the child will not be anxious. In either case, it may be beneficial to start by calling the child's name in situations where the clinician already has the child's attention, such as a physical or social game, in order to accustom the child to hearing his name called during a positive experience.

Responding to a name call is a prelinguistic skill typically developed in early infancy and is a building block for joint attention skills. Targeting the head turn in response to a name call might be an advantageous skill taught in combination with other joint attention goals. Joint attention abilities in early years are crucial to social interaction and language development, and if these skills are targeted in intervention, it could potentially lead to better outcomes in the deficit areas associated with ASD.

Literature regarding joint attention interventions suggest using a child's interest to engage in attention sharing is typically more successful than directing his attention to something new (Siller & Sigman, 2002; Leekam, et al., 2006). Dawson suggested children with autism are not likely to engage in joint attention activities purely for the shared social experience. Therefore, synchronizing attention with the child through his interest or focus of attention allows a caregiver or therapist to model joint attention and language skills (Dawson, Toth, Abbott, Osterling, Munson, Estes, and Liaw, 2004).

Limitations

Due to the nature of secondary data analysis, several factors were not ideal. For example, it may have been beneficial to obtain the heart rate data from subsequent trials, if the trials had been presented among other stimuli occurring at more random intervals to prevent the child from becoming habituated to one stimulus presentation. In the experiment, the examiner started the name call trials approximately two minutes after the video had started regardless of the child's temperament or focus; however, it may have been helpful to wait until each participant was focused on the video before beginning the trials. On the other hand, due to the possibility that the video may have caused an already decreased heart rate due to sustained attention, it is possible that waiting for this engagement from each participant to begin the trials would have not made a difference in the heart rate responses.

Last, a larger number of subjects would have provided more strength in the results to detect differences between groups. In addition, it would have been beneficial to have more IBI data prior to the name call to gain a mean baseline over a longer period of time, which would even out the variability that occurs in heart rate within shorter durations.

Future Directions

A replication of this study with consideration to some of the limitations would be a valuable contribution to the knowledge base. It would also be interesting to examine the physiological data to compare lag time before each group demonstrates a change in heart rate in response to a name call to see if there are differences in response time. Another study may also investigate the developmental trajectory of responses to name call over time in order to establish whether children with ASD improve in their ability to respond to name call later in life. In addition to resolving limitations already mentioned, a larger number of participants in future studies would allow a more reliable comparison of groups. Furthermore, future research could examine heart rate in orienting response to other stimuli, either a comparison between contexts (non-social and social stimuli) or among sensory modalities (visual, auditory, and tactile stimuli).

Conclusions

In summary, this study has contributed to the field, adding knowledge about the orienting responses in children with ASD. This study discovered that young boys with ASD show a lessened behavioral response to a name call and possibly a mild aversive or startle physiological response in heart rate when compared with their TD peers. The implications of these findings suggest that in order for young children with ASD to learn to respond to their name, a clinician must assess whether a child would need either a sensitive and unobtrusive approach or a more salient stimulus. All things considered, responding to a name is an imperative fundamental skill in the early years of development, upon which later language development and other developmental milestones rely. Therefore, the knowledge attained from this and future studies about the orienting responses of children with ASD is important to our ability to teach these children skills throughout life.

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